CHAPTER 6
ASH HANDLING

6-1. General.

This chapter addresses the requirements for the ash handling system for a coal fired boiler plant.

a. Design criteria. Ash handling systems were relatively simple prior to the enactment of stringent environmental regulations during the past twenty years. The ash was commonly quenched in wet ash pits and hydraulically discharged through ash sluice trenches to a sump pit and from there were pumped to an ash fill area. Bottom ash, pulverizer or mill pyrite rejects (pulverized coal fired plants only), economizer ash and fly ash are sometimes handled by individual, independent systems in plants now being designed.

b. Methods. A well accepted method of handling bottom ash and fly ash today is by the use of pneumatic conveying systems in stoker fired boilers. Ash is pneumatically conveyed to a storage silo without coming in contact with steam or liquid. Figure 6-1 shows a typical bottom ash and fly ash conveying system. Ash dust control conditioners have been developed to mix water with dry bottom ash and fly ash in the proper proportions to reduce the fugitive dust emissions during the transfer of ash from the storage silo to either trucks or railcars. Because of higher furnace temperatures and larger ash quantities in pulverized coal fired boilers, bottom ash has been water quenched and hydraulically conveyed. Dry bottom ash systems have been limited in quantity because of dry gravity flow. Continuous removal dry bottom ash systems are becoming available and allow reconsideration of dry bottom ash handling. Water filled bottom ash storage hoppers have been designed to accommodate large ash quantities. Bottom ash is periodically removed from the bottom ash hopper and hydraulically sluiced to an ash pond or to dewatering bins. Quantity and characteristics of ash produced in a coal fired boiler, and the ratio of fly to bottom ash depends on the coal being used, steaming rate, and method of burning. These factors, along with a LCCA of available ash handling systems will determine equipment selection. This chapter will consider hydraulic, mechanical and pneumatic ash handling systems.

6-2. System design.

a. General. There are many considerations involved in selecting an ash handling system for a coal fired boiler plant. These are as follows:

b. Boiler design and configuration. The boiler determines the amount of coal to be burned, and the percentage of fly ash to bottom ash. In a pulverized coal-fired boiler approximately 80 percent of all ash is fly ash and the remainder 20 percent is bottom ash. In a stoker fired boiler approximately 20 to 30 percent of the total ash content in the coal is fly ash with the remaining amount being bottom ash. The versatility of the boilers to burn a wide range of coals should be considered to determine the highest ash production rate when sizing the system conveying capacity.

c. Disposal conditions. Disposal to an ash pond or, alternatively, to storage bins or silos is a factor in selection of equipment. Ash ponds require large areas of land and must meet environmental regulatory restrictions. Ash storage bins require less space and are environmentally more compatible than ash ponds; however, the ash must ultimately be removed from the bin and disposed.

d. Water availability. The availability of water as a source for conveying ash, its pH rating and other chemical characteristics must be considered. If the water is not recycled, the environmental regulations of the discharged water must be considered. In most localities, untreated overflow is not permitted.

e. Type of coal. The type of coal to be burned, its ash content, sulfur content and its chemical constituents have an effect on the selection of the ash handling system. The coal with the highest ash content at the maximum continuous boiler steam output rating will be anticipated to assure adequate ash handling capacity. Ash from some coals with high calcium oxide content, such as western subbituminous coal, has a tendency to solidify when it comes in contact with water and should be handled dry to the disposal areas where it can be blown underwater from a closed bed truck.

f. Design capacity. The design criteria for selection of conveying capacity will be made to require the system to operate no more than 50 percent of the time or four hours in an eight hour shift. The remaining time is used for maintenance or catch up time on the ash handling system. The conveying time is based on the coal with the highest ash content which can be used in the boilers and with a 10 percent reserve margin on the estimated percent fly ash and bottom ash.

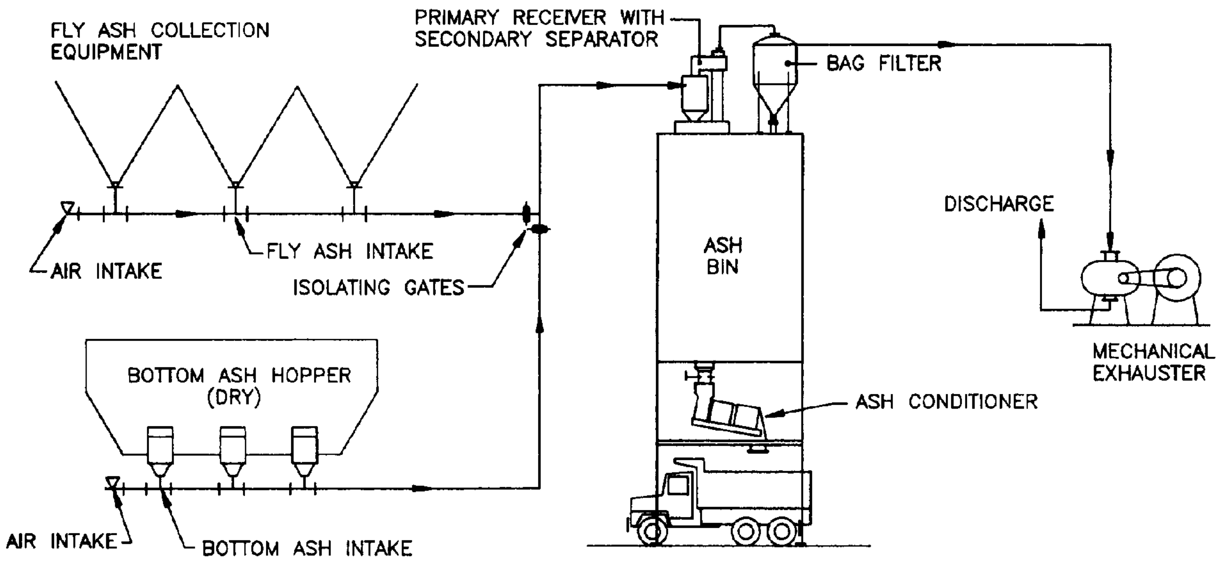

Figure 6–1. Pneumatic Conveyor—Bottom Ash and Fly Ash Mechanical Exhauster.

6-3. Bottom ash hydraulic conveying systems.

a. General. Hydraulic conveying systems are generally used for only bottom ash handling systems. Bottom ash is collected in a water impounded refractory lined steel hopper, which will be sized to store a minimum of twelve hours production of ash under the worst coal conditions at maximum continuous boiler steam output rating. The water impounded bottom ash hopper allows ash to fall through a clinker grinder or crusher where the ash is ground to a predetermined size prior to entry into a hydraulic ejector or in some instances to material handling pumps. The ash is sluiced from the plant to ash ponds or to dewatering bins. Figure 6-2 shows a typical sluice conveyor arrangement. The ash slurry is conveyed by a system of ash sluice centrifugal pumps. Ash handling pumps are discussed in paragraph 7-13. Most hydraulic ejectors are jet pumps requiring high pressure ash sluice centrifugal pumps to supply the water that is used to convey the ash to the storage area. This arrangement eliminates the need for a downstream transfer tank and the use of pumps to convey the abrasive ash slurry as shown in figure 6-3. The high pressure ash sluice pumps are also used for hopper washdown nozzles. Low pressure ash sluice centrifugal pumps supply water for bottom ash hopper furnace sealing and for coaling the refractory lined hoppers, and inspection windows.

b. Ash ponds. The ash ponds receive the ash slurry from the bottom ash hopper. Ash ponds must be sealed to prevent seepage into ground water. Ash ponds can be constructed in a manner to allow the water to be stored and returned to the plant for reuse. The ash ponds which act as a solid liquid separator must have a considerable area since retention time is the only means to allow ash to settle and separate from the conveying water. If fly ash is conveyed to the ash pond, the pond must be greatly enlarged because of the extremely slow settling rate.

c. Dewatering bins. Dewatering bins receive the ash water slurry and drain the water from the accumulated ash. Dewatering bins, like the ash ponds, can work in a closed system or an open system where water is allowed to drain to waste. In most cases the discharge of water is not allowed by regulation, so a closed recycling dewatering system will be discussed. After passing through the bottom ash hopper the ash is pumped to two dewatering bins. While one bit receives ash slurry the other bin is draining or decanting to separate the solids and liquids. The dewatered bottom ash is discharged from the bin to trucks or railcars as shown in figure 6-4. Each dewatering bin will be sized for at least 36 hour storage for a total of 72 hours storage for long weekends when trucks or rail service is not available. The dewatering bins will be designed with a 30-degree angle of repose for the ash at the top of the bins. The dewatering bins will be designed to hold the determined ash capacity at an ash/water density of 62.4 pounds per cubic foot (pcf) and be designed structurally for an ash/water density of 110 pcf. From the dewatering bins which act as the solid/liquid separator, the decanted water with some entrained ash fines flows by gravity into a settling tank for the second stage of separating the ash from the sluicing water. The settling tank

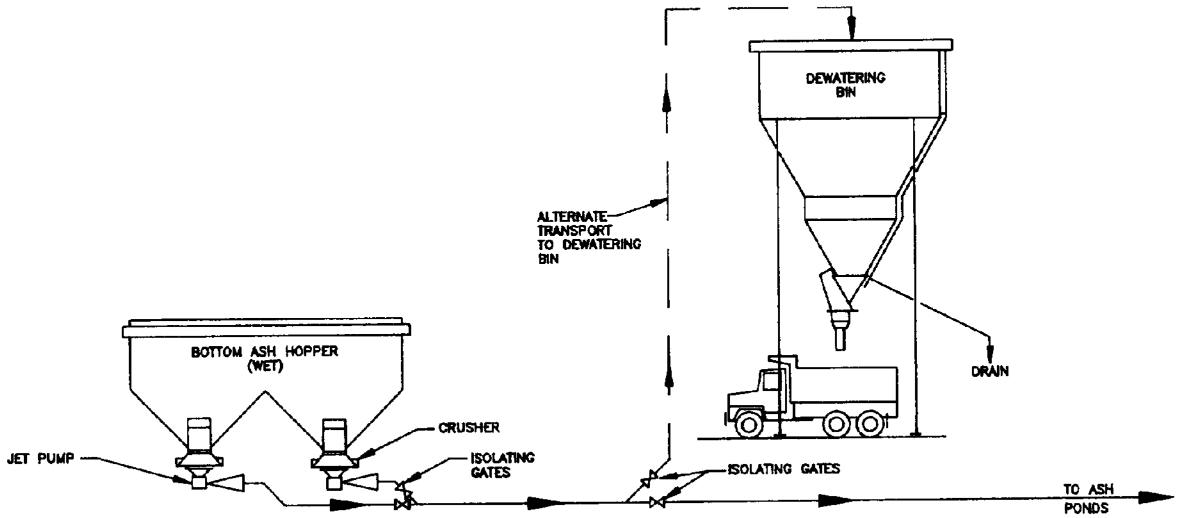

Figure 6–2. Sluice Conveyor—Bottom Ash.

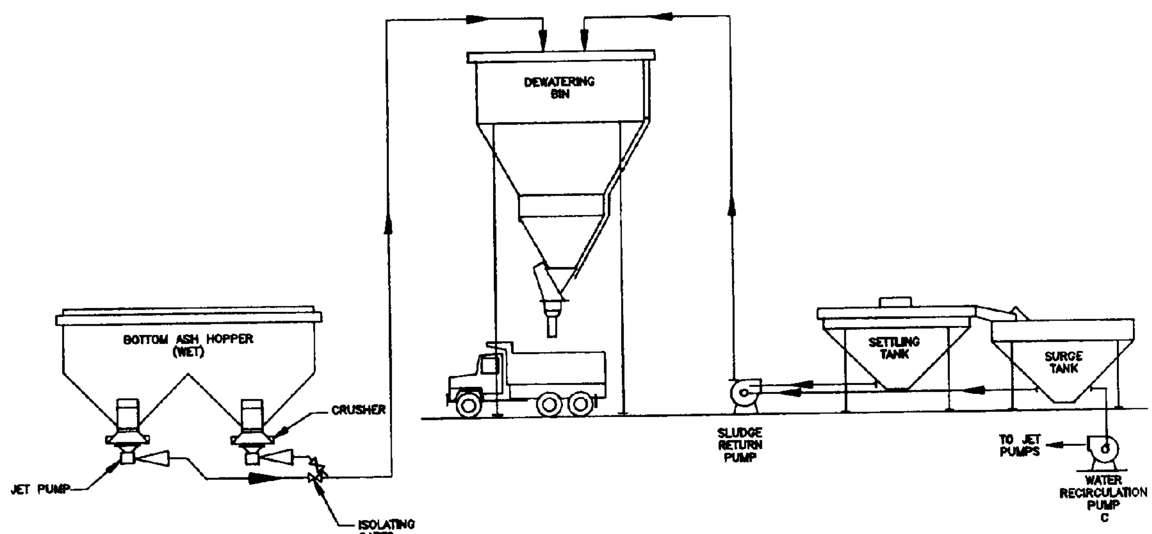

Figure 6–3. Recirculating Sluice Conveyor Jet Pump Transfer—Bottom Ash.

overflows into a surge tank which is the third and final stage of the closed recirculation system. The surge tank is sized to accommodate the overall coaling and conveying water demands of the bottom ash system. The decanted ash sluice water is returned to the ash conveying system for recycling. The ash sludge which is collected in the settling and surge tanks are returned to the dewatering bins by the use of sludge return pumps. A dewatering system is much more compact but usually more expensive to purchase and operate than an ash pond system. Climatic conditions may require this system to be enclosed and piping heat traced to avoid freeze up problems.

6-4. Bottom ash handling system alternatives.

a. Submerged drag chain mechanical transport system. Mechanical transport systems collect bottom ash in a water impounded hopper. The hopper includes a water seal to prevent escape of the boiler furnace flue gases into the environment and to prevent ambient air from entering the boiler. The

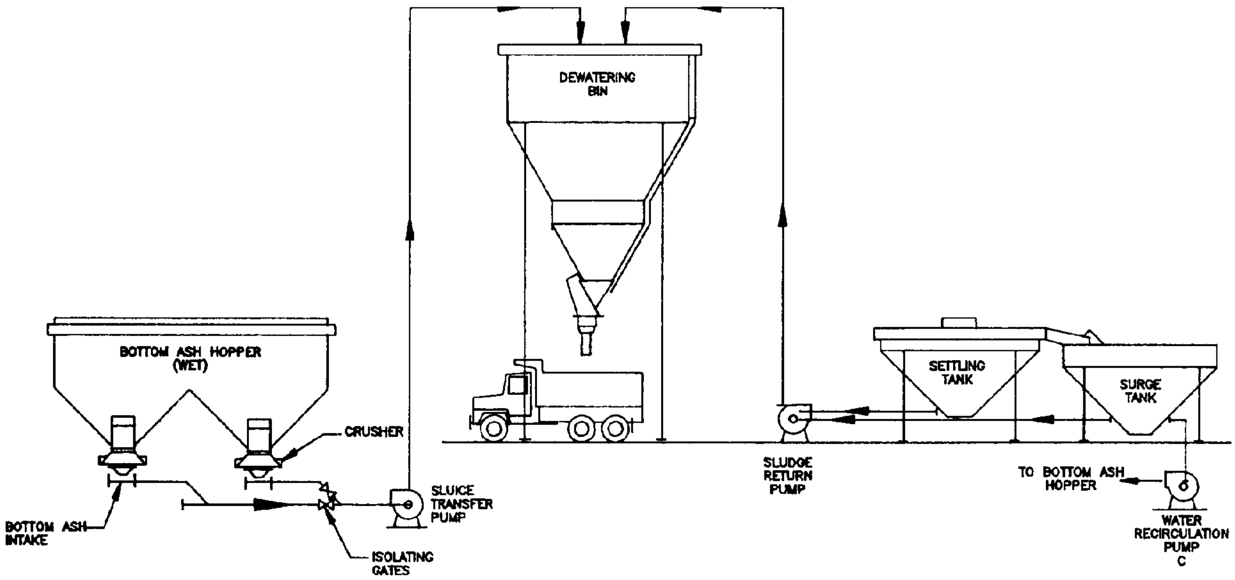

Figure 6–4. Recirculating Sluice Conveyor Mechanical Pump Transfer—Bottom Ash.

ash is continuously removed by a submerged scraper conveyor. The ash is then conveyed to either a storage bin with a capacity of up to three days or to a bunker for front end loader/truck removal. The water is recirculated into and out of the submerged trough to maintain a temperature below 140 degrees F. Overflow water from the trough is filtered through tanks before it is recirculated into the system. Surge tanks are small compared to the dewatering system tanks.

b. Sizing. The submerged scraper conveyor must be sized so that the rate of ash removal will be at least as great as ash production at maximum continuous boiler steam output rating under worst fuel conditions. Mechanical transport has several advantages over hydraulic transport. The ash removed is dewatered, it requires a lower boiler setting height and reduces power and water consumption. However, ash storage in a submerged scraper conveyor is limited and maintenance must be done in a relatively short period of time. Expensive standby conveyors and transition hoppers are often needed to provide time to perform maintenance. The submerged scraper conveyor is not commonly used in the United States because the reliability of the system in past years has been too low. There is some renewed interest by industry in the use of this type of system because of the recent improvements in the reliability and its wider acceptance in the European countries. Also in current use in Europe is a continuous dry removal system utilizing moving stainless steel belting and introduction of additional air to complete combustion and cool the ash.

6-5. Fly ash pneumatic systems.

a. Pneumatic systems. This type of system is usually used to transport fly ash from the fly ash collection equipment storage hoppers to the ash storage silo. The tendency of some types of fly ash to form scale inside hydraulic fly ash conveying lines and its extremely slow settling rate in water when coupled with the environmental liquid discharge limitations have severely restricted the use of the wet type fly ash conveying system. An advantage of pneumatic systems is they can be applied to both fly ash and bottom ash for stoker fired or fluidized bed boilers simplifying ash conveying and storage as shown in figure 6-5. Pneumatic systems are either vacuum or pressure types of system. A vacuum system pulls ash from the fly ash storage hoppers by means of mechanical, steam or water powered exhausters and a filtering system. Vacuum systems, depending on capacity requirements, line configuration and plant altitude may be designed for vacuum levels ranging from 8 to 20 inches Mercury (Hg). Vacuum systems are generally preferable to pressure systems because the system piping joint leaks pull air into the system leaving a cleaner environment. A vacuum system is recommended for capacities of less than 60 tph per system. If the conveying distance is at a remote location of over 800 feet from the boiler plant an evaluation will be made to determine whether a vacuum or pressure system is more feasible. A comparison of vacuum systems and pressure systems are shown in table 6-1.

b. Pressure systems. A pressure system engages a positive displacement blower producing pressures

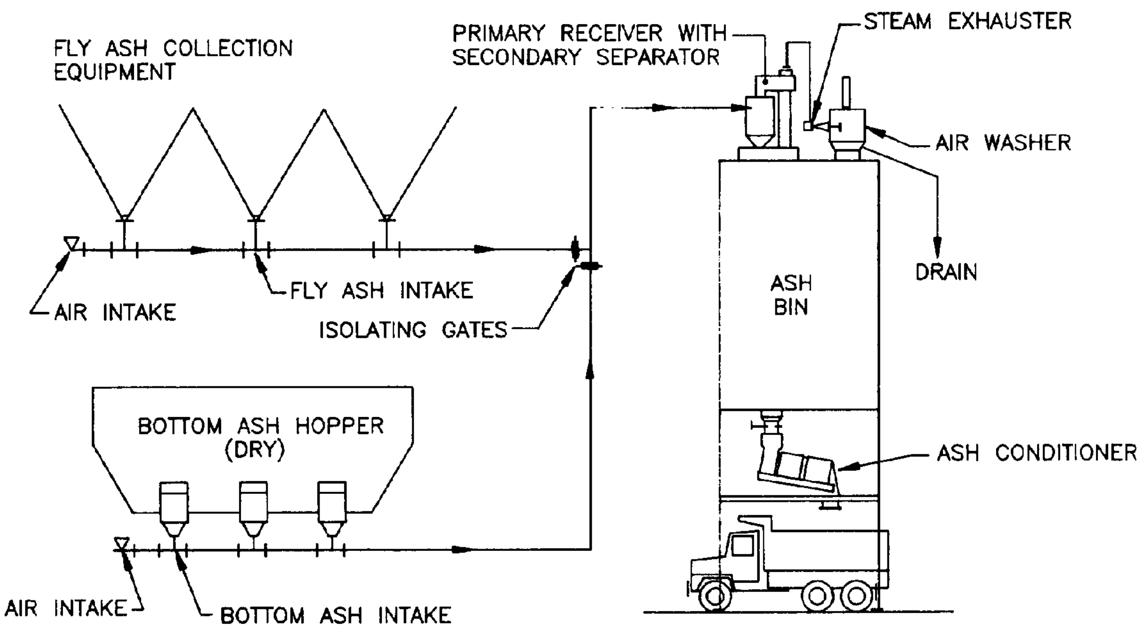

Figure 6-5. Pneumatic Conveyor—Bottom Ash and Fly Ash Steam Exhauster.

up to 20 psig for the conveying system as shown in figure 6-6. System capacity and long conveyor distances sometimes require higher blower pressures. Pressure systems may be used in lieu of vacuum systems because of higher capacities or longer conveying distances. Pressure type system should be avoided where possible because leaks of fine ash particles usually occur at the piping joints. Silo storage design is the same for a pressure system as for a vacuum system except that ash collectors are not required at the silo and fly ash is redeposited directly into the silo. There are two types of pressure systems, the dilute phase and dense phase. The dilute phase system usually has an ash to air volumetric ratio of 15 to 1 and sometimes it is as high as 30 to 1. A dense phase system has an ash to air ratio of 40 to 50 to 1 and is sometimes as high as 80 to 1. Vacuum systems are classified as dilute phase. A comparison of pressure dilute phase and dense phase systems is shown in table 6-2. The dilute phase pressure system is the more widely used pressure system. Dense phase pressure systems utilize a fluidizing transporter, a vessel in which air and ash is mixed, fluidizing the ash so that flow characteristics resemble that of a liquid.

c. Vacuum/pressure systems. In some rare cases, it may be more economical to combine a vacuum system with a pressure system where distance rules out the use of a vacuum system alone. Figure 6-7 shows a typical vacuum/pressure system. The vacuum system, with its simplified controls, removes ash at an optimum rate. The pressure system, reduced to one transfer point with a minimum of controls, then delivers collected ash to any terminal point at a distance of several thousand feet. The vacuum pressure system provides the least complex controls of any long distance pneumatic conveying system.

d. Ash storage silos. Storage silos are usually constructed of carbon steel because of its lower cost and durability. Hollow concrete stave construction or reinforced concrete construction are sometimes used. The bottom of ash storage silos are equipped with aeration stones to fluidize the ash and induce flow from the silo to the discharge outlets. Silos will be designed for a minimum of sixty hours of storage, based on the design and production rate, utilizing an ash density of 60 pcf. The actual ash density can vary from 60 pcf depending on the coals being fired. The silo support structure will be designed for a full silo with fly ash density 100 pcf.

6-6. Controls

a. General. Programmable type control systems are used for both automatic and semi-automatic control. Older systems used electromechanical type control systems, many of which are still in operation.

b. Types.

(1) Programmable controllers (PC) have been applied to ash handling systems with good success during the last fifteen years and are the

Table 6-1. Comparison of Pneumatic Vacuum Versus Pressure Ash Conveying Systems.

	Vacuum Systems	*Pressure Systems*
When Recommended		
	Convey systems less than 60 TPH per system.	High system capacity.
	Reasonable conveying distance.	Long conveying distances (greater than 1000 to 2000 feet).
Advantages		
	Less maintenance at hoppers.	Relative unlimited capacity.
	System leaks inward for cleaner environment.	Relative unlimited conveying distance.
	Multiple collecting points.	No separating equipment.
	Simpler control scheme.	Clean air blowers multiple disposal points.
Disadvantages		
	Requires separating equipment and process bag filter.	Double gates required with air lock.
	Blower life dependent on separating equipment reliability.	Air lock pressurizing and venting requires additional piping and valving.
		Ash leaks outward into the plant.
		Higher maintenance costs.

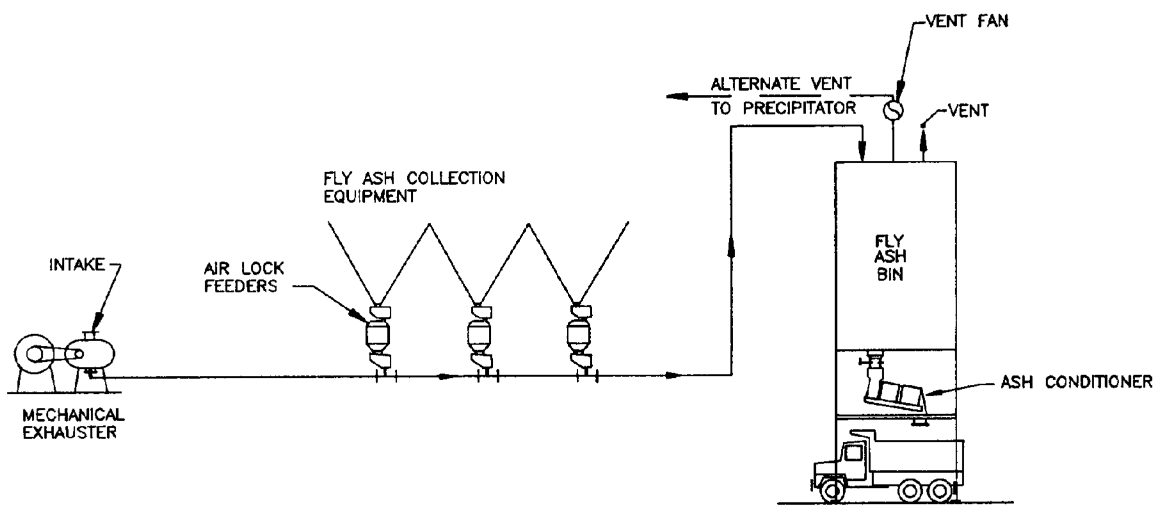

Figure 6-6. Pneumatic Conveyor—Pressure System Fly Ash.

most preferable type of control. The PC's ability to perform relay logic, timing, counting, and sequencing functions, provides a way to perform the tasks required for ash handling system control. A number of higher level PC's also offer more enhanced capabilities such as instruction, sophisticated report generation and off-line programming. The PC performs all ash handling controls and allows flexibility in control schemes giving the user many benefits. The PC has a memory and is programmable, providing the user with the ability to change the ash handling sequence and timing and gives him the ability to troubleshoot, modify and expand with the system.

(2) Before the advent of the PC, both the bottom ash and fly ash made extensive use of the drum sequencer, electromagnetic timers and counters, and relay logic. The disadvantage of the electromechanical system is the large amount of relay control required for the drum sequencer; the periodic maintenance required for the drum sequencer, the large amount of panel area required; the extensive wiring; and the inflexibility of the system when changes are required.

Table 6-2. Comparison of Pressure Dilute Phase and Dense Phase Pneumatic Ash Conveying Systems.

	Dilute Phase	*Dense Phase*
Design Criteria	Evenly loaded single conveying line. Loading ratio (5 to 22) lbs. of ash to lb. of air. 10 to 30 psig operating pressure. 2000 to 3500 ft per mm starting velocity.	Typically multiple convey lines. Loading ratio (20 to 200) lbs. of ash to lb. of air. 30 to 100 psig operating pressure. 600 to 3000 ft per min starting velocity.
When Recommended	High conveying capacity (greater than 30 TPH) Long conveying distances (greater than 1000 ft).* Multiple disposal points. Minimum collection points.	Short conveying distances (200 to 500 ft).* Medium capacities (10 to 50 TPH). Minimum collection points. Minimum disposal points.
Advantages	Greater capacities and distances with single line. Not affected by material changes with gravity flow. Stable velocity range provides material re-entrainment. Transfer stations normally not required. Low initial cost air handling equipment Components subjected to lower pressure.	Smaller conveyor lines, bag filters and hoppers. Lower conveying velocity. Normally lower horsepower. Carbon steel pipe.
Disadvantages	Higher airflow, larger pipe, and hoppers. Often higher horsepower. Components subjected to higher velocity, Special pipe required-alloy pipe or ceramic lined pipe.	Material consistency greatly affects conveying parameters and granular material remains in airlock with top exist. Positive sealing high differential discharge valve is critical to system performance. Transfer stations normally required. Parallel compressed air lines required to free line plugs. Multiple conveyor lines. Expensive initial cost air compressors. Components subject to higher pressure.

*An evaluation should be made for conveying distances of 500 to 1000 ft to determine whether Dilute Phase or Dense Phase pneumatic ash conveying systems are more feasible.

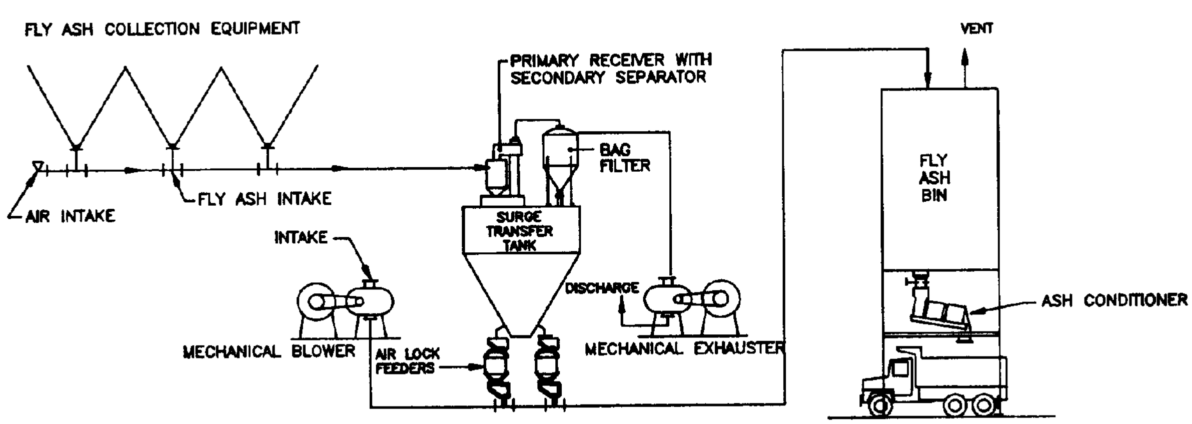

Figure 6–7. Pneumatic Conveyor—Vacuum System and Pressure System Fly Ash.